ISSUE PAPER

The Use and Effect of Computer-Based Training in Health Care: *What Do We Know?*

Executive Summary

For the last decade, stand-alone training offered on computers has been used extensively in the U.S. for training medical students and health providers. In many instances, health providers have demonstrated improved knowledge scores upon completing computer-based tutorials, and when compared with traditional facilitator-led training, computer-based training has yielded equal and sometimes higher test scores. There remains, however, serious questions about the long-term performance of providers after using computer-based training and the cost issues associated with its development and implementation.

In the following paper, QAP reviews the current body of published and nonpublished research on the effectiveness of computer-based training in health care. Special focus is made on its implementation in developing country settings and on areas of research that QAP feels should be addressed.

Introduction

Classroom-based, facilitator-led, off-site training of health providers, often followed by a training of trainers (TOT) or cascade training, has generally been the approach funded by international health donors, organizations, and ministries to address critical deficiencies of appropriately skilled health providers in the developing world. Recent quality assessments suggest that despite large investments, this type of training has a limited impact on quality of care.[1] As a result, international health organizations and donors have begun emphasizing the importance of innovative approaches to providing preservice and inservice training for health professionals in developing countries, including utilizing state-of-the-art methods of communication.

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QAP
The Quality Assurance Project is funded by the U.S. Agency for International Development, under Contract Number HRN-C-00-96-90013. QAP serves countries eligible for USAID assistance, USAID Missions and Bureaus, and other agencies and nongovernmental organizations that cooperate with USAID. The QAP team, which consists of prime contractor Center for Human Services, Joint Commission Resources, Inc., and Johns Hopkins University (JHU) provides comprehensive, leading-edge technical expertise in the research, design, management, and implementation of quality assurance programs in developing countries. Center for Human Services, the non-profit affiliate of University Research Co., LLC, provides technical assistance in the design, management, improvement, and monitoring of health systems and service delivery in over 30 countries.

Operations Research Issues Paper
The Operations Research Issues Paper presents important background information about key subjects relevant to QAP's technical assistance. The series provides a review of the state of the art in research on a subject (both published and non-published, theoretical and operational); along with recommendations for research questions and productive lines of inquiry for QAP's technical staff and external researchers and health professionals.

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This interest has stimulated a number of organizations, such as the Quality Assurance Project (QAP), to expand the boundaries of health worker training through the educational use of computers or computer-based training (CBT).[2] QAP is studying and implementing cost-effective interventions in international health care that improve the quality of health care delivery and overall health outcomes.[3] QAP believes that CBT represents a potentially cost-effective alternative training approach for training health workers in a variety of health topics and in quality assurance (QA). A review of the current body of quantitative and qualitative research on the cost savings and effectiveness of the CBT format for health care providers appears on the following pages. The focus is on programs that allow mutual prompts between learner and software and that the learner can access at will. Most of the studies discussed concern the use of CBT in health care settings in the United States; we also include experiences in developing country settings.

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Definition and Characteristics of CBT

Various terms are used to describe the educational use of computers (see sidebar at right). In this paper, we use the term "computer-based training" (CBT) to refer to training in which the subject matter is primarily presented through a computer, as opposed to traditional training led by a facilitator or instructor.

Types of CBT

There are four levels of CBT, each based on the application's complexity and its level of interactivity with the user (Dulworth and Carney 1996).[4]

- **Level I: Customized linear presentation.** Training similar to a standard PowerPoint overhead presentation with little interactivity
- **Level II: Instructor-led, nonlinear presentation.** Training by a facilitator accompanied by navigation through the information on the computer, without the use of multimedia
- **Level III: Facilitator-led training.** A multimedia presentation accompanied by classroom-based training
- **Level IV: Self-paced training.** A multimedia presentation that trainees use independently with minimal assistance (also known as "stand-alone training"). Individuals can train at their own pace, either at an outside lab or on their own desktop computer, and complete the exam provided in the program.

Levels II, III, and IV are the types of CBT that would be most effective in addressing performance gaps among international health workers. To qualify for these levels, a CBT program must meet the following commonly accepted criteria (Dickelman 1992):

- Be easy to enter and exit
- Provide a simple way to move forward and backward (i.e., from screen to screen)
- Be consistent in its key conventions
- Offer context-sensitive prompts and helps
- Provide tracking feedback (e.g., Where have I been? Where am I now? How much more is there to go?)
- Offer bookmarks (i.e., quit now, resume later)
- Always offer a way out

Generally, CBT application design can be grouped according to Romiszowski's environmental classification into three types of environments: prescriptive, democratic, and cybernetic (Romiszowski 1994).

The different terms coined to describe the educational use of computers are often used interchangeably, although the individual meanings may be technically different. Because the terminology can be confusing, we present below the attempts of some researchers (Calderone 1994; Dickelman 1994; Chambers and Frisby 1995; Cotton 1995) to standardize some of the definitions.

CAL *(computer-assisted learning)* and **CBE** *(computer-based education)*. All-encompassing terms for any kind of computer application used for learning. Includes word processing programs, games, and tutorials either as stand-alone or instructor-facilitated, computer-learning activities.

CAT *(computer-assisted testing)*. Assessment conducted through the medium of a computer. An individual takes the test at the computer, and the computer records responses and scores the test. CAT is embedded in most computerized training.

CBT *(computer-based training)* and **CAI** *(computer-assisted instruction)*. An interactive learning experience in which the computer provides most of the stimuli, the learner responds, and the computer analyzes the responses and provides feedback to the learner. Components most often consist of drill-and-practice, tutorial, or simulation activities offered alone or as supplements to traditional instruction.

CMI *(computer-managed instruction)*. Refers to: (a) the use of computers by school staff to organize student data and make decisions or (b) activities involving computer evaluation of student test performance and guidance to appropriate instructional resources.

IVI *(interactive video instruction)*. Integrates the computer's capacity for interactivity, information management, and decision-making with the audiovisual capabilities of videodisc or videotape. May combine a variety of media stored on a videodisc, such as full-motion video, readily accessible for viewing. Proven to be as effective as other computer approaches and traditional training but generally much more costly in terms of both hardware and software. QAP is currently exploring potentially cost-effective IVI training approaches suitable for developing countries.[5]

- **Prescriptive:** Programs that are usually developed as tutorials, drill-and-practice, and games. Typically, they are not flexible; that is, the application cannot sense the user's level of knowledge and adjust the presentation accordingly. The trainees can access different areas of the application based on progress and skill but must proceed through a specific module or area before advancing to the next step.
- **Democratic:** Programs that permit the learner to influence what is learned and how it is learned, or at least the order in which it is learned. Thus, learners have the option of selecting sections according to their preference and moving along different pathways toward the same final goal.
- **Cybernetic:** Cutting-edge systems that use artificial intelligence to teach

Advantages and disadvantages of CBT

CBT offers learners the ability to use a computer independently or with fewer interactions with an instructor than usual. This is a promising innovation, especially for health care settings located far from a training facility in areas with poor transportation. However, CBT also has its disadvantages, particularly in the developing world (see Table 1).

CBT in Health Care

CBT has been a feature of medical training programs since the mid-1980s. Objectives have ranged from teaching specific topics to premedical students, such as fundamental electrocardiography and knowledge of dementia (Fincher et al. 1988), to training nurses in critical thinking skills (Perciful and Nester 1996).

In the health setting, CBT can be delivered in a preservice or inservice mode, as follows:

- **Preservice training.** Computerized training delivered in health education, nursing, and medical school curricula through the use of software tutorials with or without professor facilitation, followed by examinations programmed in the computer program or given by an instructor.
- **Inservice training.** Health workers use CD-ROMs independently on their own computers for stand-alone training, meet at a computer lab where facilitator-led courses are coupled with the computer program, or attend the lab according to their own schedules and review the materials at their own pace.

Research has shown that computer training is particularly well suited to visually intensive, detail-oriented subjects, such as anatomy and kinesiology. This is because it allows text to be combined with still and moving graphics, with the display of this information controlled by the learner (Toth-Cohen 1995). For example, points out Phillips (1996), computers can be particularly effective in presenting:

- Subjects that are difficult to conceptualize, such as microscopic processes
- Material that is three-dimensional and difficult to visualize on traditional two-dimensional media such as books or white boards
- Simulations of expensive or complex processes, where the mechanical details of performing the process or the impossibility of using the real equipment, may hinder understanding

The use of computer-generated images and simulated clients for practicing and testing diagnostic skills has practical advantages for medical schools seeking to develop students' competencies and knowledge in realistic situations. Researchers and medical school planners have maintained that CBT's greatest contribution is in simulating the kinds of real-life situations likely to be encountered by the medical student without the need to actually re-create them. Thus, patient care is not compromised and students have the opportunity to learn from their errors without fear of harming the patient (Lassan 1989).

Based on their experience in developing a CBT program for rural health workers in the United States, Aegerter et al. (1992) believe that of the four major steps of medical practice—examination, diagnostic decision, therapeutic decision, and therapeutic action—diagnostic and therapeutic decisions are conveyed best in CBT.

At times, CBT is not optimal for teaching subject areas that require relatively sophisticated technology, such as the cognitive aspects of psychomotor skills that involve evaluation of such outcomes as a patient's respiratory rate. When psychomotor skills are a component of CBT in a classroom setting, the facilitator usually reviews them in a separate module (as technology advances, this two-pronged approach will become less necessary).

In a study by Christenson et al. (1998), students who took a stand-alone multimedia course and students in traditional training showed that they achieved equal scores in performance and knowledge; however, a significant number of the multimedia group required retraining before they could successfully complete the mock cardiac arrest practicum (the actual demonstration of psychomotor skills). Nevertheless, the researchers did note that more than "half of the multimedia students were able to successfully complete the mock arrest with only a 30-minute orientation to the mannequin after the multimedia course."

Table 1 ■ Advantages and Disadvantages of CBT

Advantages	Disadvantages
■ **Self-paced**. Each learner can progress at his or her own pace, control the rate and sequence of instruction, and select repetition and feedback.	■ **Technical support necessary**. Multimedia always requires appropriate hardware and software such as processor, video card, sound card, speakers. Computers need to be maintained by skilled personnel. Obviously, a stable electric supply and surge protectors are key. For certain developing country settings, these conditions are not currently feasible.
■ **Interactive**. Microcomputer systems incorporating various software packages are extremely flexible and maximize learner control.	■ **High development costs**. The time it takes to develop, review, revise, pilot test, debug, and finalize the program is extensive. Implementing the programs and getting them to the users is expensive, and the more interactive the program, the more expensive it is.
■ **Just-in-time**. Easy access to training (for those with computers) means workers can immediately apply knowledge and skills to the job, thus quickly improving performance.	■ **Rapid change in technology**. Computer technology evolves so quickly that training solely focused on innovation requires constantly updated equipment that can keep pace with technical advancements.
■ **Inexpensive**. Computer innovations are constantly emerging, while related costs are dropping. Cost savings increase over time as up-front development costs are absorbed. Because CBT usually takes less time than traditional training, students may complete their course of study without suffering the loss of salary due to having to attend lengthy courses or relocating.	■ **Poor knowledge of computers/technophobia**. Widespread computer illiteracy and fear of computers still exist in many settings.
■ **Accessible**. Students in rural areas can learn without incurring lengthy transportation costs.	■ **Poor access**. Although computers have been widely used since the 1960s, many learners do not have access to them or computer networks. In developing countries, computers are typically found only in the capital cities.
■ **Satisfying**. The computer is nonjudgmental and nonthreatening. It provides a privacy that reduces learners' embarrassment about doing remedial work or making mistakes when answering questions.	■ **Inadequate programs**. Individuals not directly responsible for teaching students frequently develop CBT programs.
■ **Consistent quality**. Students can be exposed to the expertise of the most qualified faculty, with minimum variation from instructor to instructor or class to class.	

Source: Lassan 1989; Mulligan and Wood 1993; Wills 1993; Lancaster and Willis 1994; Chambers and Frisby 1995; Dulworth and Carney 1996.

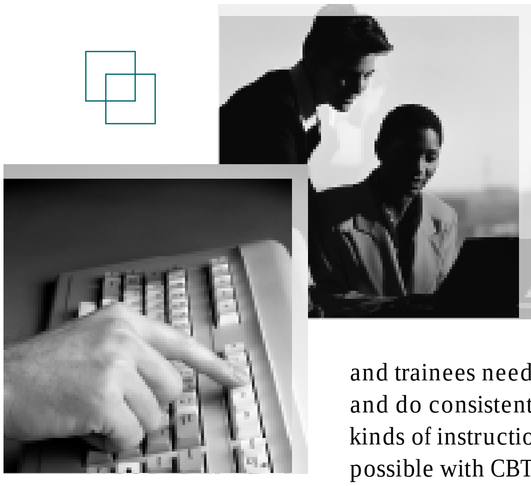
When Dewhurst et al. (1994) used CBT to teach intestinal absorption, students complained that the CBT training format did not prepare them to master lab equipment successfully because they did not actually use the equipment in the course.

In addition, stand-alone CBT is of limited use for training in social principles, such as conveying empathic inpatient counseling, because it cannot adequately evaluate the diverse set of learner responses involved in such an action (Clark 1992).

Historical development

Approaches to developing and evaluating CBT are largely derived from the field of instructional design. Instructional design employs principles, models, activities, and other techniques that are intended to involve an audience systematically and communicate information to them reliably. Instructional designers create programs, curricula, and projects that make information exchange as efficient and effective as possible (Utvich 1995). Performance objectives, lesson content and format, and a plan for formative evaluation all derive from varied input, for example, audience analysis, theories of learning, and other external data (Gagné et al. 1988; Toth-Cohen 1994). Underlying this field are bodies of theory drawn from a number of disciplines such as behavioral and cognitive psychology, communication theory, and general systems theory (Foshay and Miller 1992).

According to Fletcher (1990), people retain only 20 percent of what they hear; 40 percent of what they see and hear; and 75 percent of what they see, hear, and do. CBT development is based on the premise that, to learn most effectively, students



and trainees need to see, hear, and do consistently. Among the kinds of instructional strategies possible with CBT are animated and color-rich screen designs with the ability to display information only when needed, on-line interactive drill and practice techniques, audio prompts and feedback responses, and practice sessions using touch-screen displays (Clark 1992}.

CBT developed as a result of the limitations of traditional teaching approaches. A body of research (Bojan et al. 1995) has shown that "the didactic approach to teaching… does not encourage an analytic approach [to students' thinking]." According to Mulligan and Wood (1993), there is a noticeable "lack of active decision making" in the traditional classroom approach to learning. In a review of nursing education, Grobe (1984) emphasizes that "our current lecture approaches generally seem to teach *about nursing* and not necessarily *how to nurse*." Lyon et al. (1992) cite in their criticism of traditional medical education an "ever-growing discrepancy between the continuously increasing multitude of acts and the low level of understanding of how to use them."

In the United States, CBT emerged not only as an alternative to traditional training, but also as a practical solution to the problem of training with limited resources. Proponents feel that CBT is cost-effective: It minimizes the need for paid trainers, the printing and updating of paper materials, and resources that need to be rented or scheduled. At the same time, CBT permits a larger number of health care workers to be taught at the same time. Costs decrease in proportion to the number of learners using CBT programs, whereas costs for classroom instruction increase in proportion to the number of learners. CBT has also been shown to require less time of trainees than traditional training. In addition, for those with comptuers, CBT is always accessible to the learner, and can be interrupted and resumed at will (Lassan 1989; Mulligan and Wood 1993; Lancaster and Willis 1994; Chambers and Frisby 1995; Dulworth and Carney 1996).

One CBT program was developed at the Faculty of Health and Social Care at Leeds Metropolitan University because the department was "under considerable pressure to increase student numbers with no comparable increase in resources and to reduce staff-student time" (Dewhurst et al. 1994).

Attempts to bridge the gap between theory and practice in traditional medical training are largely limited to time-consuming hospital-based case presentations. CBT was developed as a response to this problem because the format makes it easier and less expensive to study realistic cases. CBT is also lauded as a remedy to resource constraints on health care training for use in tropical settings. These constraints include the heavy workload of doctors, limited availability for time-consuming explanations, scarcity of patients with rare diagnoses to use in training situations, low number of training staff among medical staff, geographic restriction on types of diagnoses that can be studied, and the high cost of travel to training sites (Van den Ende et al. 1997).

Another practical reason for the use of CBT in medical education is the desire to avoid the use of animals or animal tissue for the sake of learning (Dewhurst et al. 1994, Coleman et al. 1994).

Relevance of CBT to quality assurance in health care

Dr. W. Edwards Deming, a guru in the quality field, has outlined 14 points important to maintaining quality; these have provided a philosophical basis for today's quality movement. One of his points is that quality organizations should institute a continuous program of education and retraining that gives workers a share in the philosophy and goals of the organization, an understanding of their jobs, and specific procedures to do their jobs correctly (Walton 1986). He also holds that evaluation of learning achievement when training is completed will improve quality (Gitlow et al. 1989).

Having well-trained and competent workers is a goal of any quality organization, but traditional training has several limitations. For example, the training itself often disrupts trainees' work for extended periods of time. It is also possible that the knowledge and skills acquired during training may not be applicable to the trainee's work. In addition, training sites often do not reflect the true work situation in the field (Bradley et al. 1998). In such situations, training can actually result in a decrease rather than increase in the level of quality.

Health organizations are looking for alternative training approaches that address such basic tenets of quality as continuity, efficiency, effectiveness, and technical competence (DiPrete Brown et al. 1998). CBT, when used as a stand-alone training for health care workers with unlimited access to a computer, addresses the issues of continuity; it opens the way to training health workers at preferred times and locations, thereby minimizing or eliminating interruption of health care delivery. CBT programs used at a learner's own pace considerably reduce instructional time for some trainees. Efficiency enters the picture because of the adaptability of many CBT programs to independent study, on-site classroom, off-site classroom, or distance learning. And when soundly designed, CBT addresses effectiveness and technical competence with its embedded assessment of performance.

Training is an integral component of a quality assurance (QA) effort. Frequently, considerable time is involved in QA up-front training. The process often requires a change of such magnitude that it necessitates training in planning for quality and applying quality principles, tools, and techniques; forming and developing teams; and identifying the components of health care that are to be monitored and evaluated even before the actual QA effort begins.

Costs decrease in proportion to the number of learners using CBT programs, whereas costs for classroom instruction increase in proportion to the number of learners.

Quality practitioners are, therefore, interested in innovative training approaches that can decrease the time and resources required for QA training. CBT is a training strategy that can possibly address this need. At workplaces where computers are available, CBT can provide on-line QA tools that health staff can easily access. McAlindon and Smith (1994), in their use of interactive video instruction (IVI) to teach principles of quality improvement to nurses, found that the nurses gained a significant increase in knowledge and a slight, albeit insignificant, gain in appreciation of QA. Additionally, a significant number of the nurses expressed a willingness to apply the QA principles they had learned from the IVI program to patient care.

Studies of CBT in Health Care

The studies discussed in this section were selected because they had one or all of the following characteristics:

- The population of interest comprised medical students (working toward a diploma or baccalaureate) or health providers in practice or training
- The intervention under research met the appropriate criteria of a CBT product
- The outcomes assessed were either a combination of overall achievement as measured by posttest, retention, attitude toward CBT, cost-effectiveness, time to learn, performance of skill, and/or competence of trainees

This review is not an exhaustive analysis, but rather a sampling of most of the last 10 years of research on computer-based training in health care. A drawback of the analysis is a lack of study comparability and external validity of results and the publication-selection bias among the studies. The wide range of research designs, intent of interventions, sample sizes and variability, settings and populations, and criteria for outcome measures makes direct comparison impossible.

CBT has been used much more extensively in preservice training than in inservice training. This is likely due to the availability of computer labs in medical institutions, the familiarity that younger students just beginning their medical training have with computers,[6] and the irregular opportunities that inservice providers have to meet for training as a group or to be available to study over a period of time (Handler 1995).

CBT compared to traditional training

As interest in CBT as an alternative to traditional training has grown, both kinds of training approaches have been increasingly researched and compared. Numerous studies in health care alone show that CBT is equally effective, and occasionally more effective, than traditional training. In their review of 11 studies measuring the effectiveness of CBT in nursing education, Belfry and Winne (1988) found that students had a more positive attitude toward CBT than toward lectures. They also scored higher in tests and learned the material they needed to know in less time than traditionally instructed students. Cohen and Dacanay (1994) and Fieschi et al. (1994) examined 29 studies where 22 of the study populations receiving CBT had higher examination scores than those with traditional training. In six of the studies favoring CBT, the difference between computer-based and traditional training was statistically significant.

Many of the studies shown in Tables 2 and 3 did not obtain a statistically significant improvement with the use of CBT compared to traditional training. But, as Schmidt et al. (1991) noted, "…the importance of [these studies] is not in [their] ability to find significance between the two teaching methods, but rather in its affirmation of the effective use of computer technology in the educational setting." Indeed, there is not one study demonstrating a significant increase in exam outcomes for traditional training compared with CBT.

In a study by Halloran (1995) on the use of CBT in surgical nursing, no statistically significant difference was found in achievement between the CBT and traditional groups. However, the CBT group showed a trend toward improved examination grades as the semester progressed. The researcher hypothesizes that this improvement may have been the result of increased student comfort with the new manner of presentation, and that the lower scores on the initial tests may have been an artifact of vampire video (in other words, the method of presentation was so exciting or unusual that it overshadowed the content or message).

Unfortunately, these studies do not include discussion of what makes a particular CBT package either equally or more effective than traditional training (Keane et al. 1991).

Cost-effectiveness of CBT in health care

Development of CBT frequently has been justified on the basis of increased savings. Proponents claim that delivery costs for CBT are reduced because hiring and opportunity costs (incurred when instructors and experts leave their regular duties to teach a class) are eliminated. In addition, when CBT is used together with facilitator-led training, it often reduces the time that students and instructors must spend in class.

Kulik (1994) found time reductions of 34 percent in 17 studies of CBT use in higher education and a 24 percent time reduction in 15 studies of adult education. In their review of CBT used in military training, Orlansky and String (1977) found that reductions in time to reach instructional objectives averaged about 30 percent.

Only a few studies of CBT in health care attempt to document any costs saved or associated with the delivery of CBT. In one of the most rigorous research designs to date of CBT in health care, Lyon et al. (1992) found that the CBT group spent significantly less time (43 percent) to achieve the same level of competence in clinical problem-solving as a traditional training group spent in diagnosing anemia and coronary artery disease. Lyon et al. also found that substituting CBT for traditional training eliminated 96 faculty hours of traditional direct student contact after class. Dewhurst et al. (1994) calculated costs in their study comparing a computer-simulation program and a traditional laboratory practical class for teaching the principles of intestinal absorption. They found that the computer-based approach was five times less expensive than the traditional laboratory approach, yet resulted in equal knowledge scores. Preliminary results from Kekiitinwa and Tavrow (unpublished) indicate that using CBT for training health workers in the Integrated Management of Childhood Illness (IMCI) results in a 20 percent cost savings, if hardware costs are not included.

Hulsman et al. (1997) noted that their CBT course on communication skills for medical specialists was given over three hours rather than the conventional two to three days, but made no evaluation of which approach was preferable. Nevertheless, half of the participants in the CBT group felt that the course was rather time consuming. This study and others (Richardson 1997) signal that students taking CBT courses need frequent breaks because time seems to pass much slower for them. This extra time should be factored into cost calculations. In his analysis of the economics of using CBT delivered through microcomputers, Levin (1989) points out that costs should include expenses incurred for: (a) the time of teachers, teaching specialists, coordinators, and administrators; (b) physical space for the equipment and whatever security devices, air conditioning, or special wiring are needed; (c) computers and supporting equipment, such as printers, cooling fans, surge protectors, special furnishings, and paper for printers; (d) software and any associated instructional materials; and (e) miscellaneous items, such as insurance, maintenance, and energy.

Indeed, there is not one study demonstrating a significant increase in exam outcomes for traditional training compared with CBT.

These costs should not be ignored, although they will decrease as technology proliferates and becomes less expensive. Whitson (1996) noted that the price of computers that cost $5,000 in the late 1980s is now as low as $800 to $1,000. The UN concluded that the cost of a quadruple speed drive in 1995 had fallen to less than $200. Portability, mass storage, reliability, capacity to store multimedia, and ease of distribution have made CD-ROM technology well-adapted to developing countries (UNDP 1996). In the developing world, says Howe (1993) one cannot underestimate the recent proliferation of computers and the active dissemination of hardware and software by the United Nations Development Programme (UNDP)[7] and the United States Agency for International Development (USAID).[8]

If learning with CBT requires less time than traditional learning, both learners and faculty members could apply the time saved to other program-related tasks. Although difficult to quantify, the time saved might be shown as associated with worthwhile gains in other instructional activities (Keane et al. 1991).

Many trainers and educators enthusiastic about CBT are objecting to cost-benefit studies, holding that such studies perpetuate the view that CBT is justified primarily because it accomplishes the same results faster than traditional methods. "Those who regard technology as a tool for education reform—who see it as contributing to the adoption of a higher set of expectations for students, to more emphasis on complex tasks and collaborative learning, to a change in the roles of students and teachers—contend that an analysis showing that computers can teach lower-level skills faster than can worksheets simply misses the point" (U.S. Department of Education 1993).

Attitudes towards CBT in health care

User satisfaction with CBT is frequently measured through surveys or interviews using traditional Likert scales of satisfaction. Most authors point to usability as a key feature of quality for a CBT application. However, many state that because previous experience with computers has a significant impact on a user's assessment of satisfaction with a CBT program, satisfaction surveys are an unacceptable evaluation tool for CBT applications (Jones and McCorma 1992). Clark (1985) maintains that the level of motivation or effort that students invest in CBT depends on whether they believe it is difficult to learn from computers. However, the study by Lyon et al. (1992) does not support this hypothesis; students with both high and low expectations had similar test scores. Also, as seen in the studies featured in Tables 2, 3, and 4, a significantly higher positive attitude towards CBT does not translate into a superior learning outcome.

When trainees do have negative attitudes towards CBT, say Day and Payne (1984) and Brudenell and Carpenter (1990), it is because the programs do not challenge or stimulate them intellectually, do not offer feedback on wrong answers, do not provide a rationale for correct answers, or do not include interaction between faculty and students.

In Porter's (1991) study comparing the use of a stand-alone CBT, video, and lecture in training three groups of paramedics on responding to trauma, the most preferred format, in order of choice, was as follows: (a) lecture, video, and CBT; (b) lecture, CBT, and video immediately after training; and (c) lecture, CBT, and video 60 days after training. However, even though the lecture was preferred above all other training methods, CBT did a better job of imparting knowledge and enhancing knowledge retention.

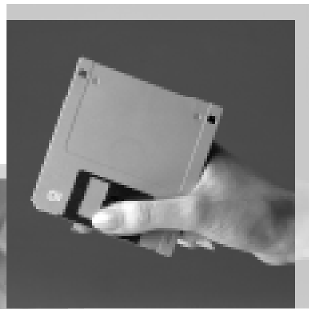
These results were similar to those found in a study by Christenson et al. (1998), in which students expressed dissatisfaction with CBT although they completed the CBT course successfully. The researchers hypothesize that the dissatisfaction reflected insecurity with taking such a course and a lack of personalized reassurance from the instructor. Hence, the investigators did not draw any unequivocal conclusions about attitudes and outcomes.

It is difficult to generalize about trainee attitudes toward CBT in health care because individual experience varies, primarily due to improvements in software quality and instructional design over the years.

In a study of CBT used in teaching clinical calculation skills by Reynolds and Pontious (1986), students, who were not randomized, chose their preferred training format from among CBT, individual faculty conferences, practice in a simulation laboratory, and peer tutoring. Seventy-six percent of students in CBT training passed their competency test, compared to 39 percent receiving the other types of instruction. A bias apparently exists among those students who selected CBT; the authors hold they are more self-directed and motivated than students choosing an alternative format. However, the authors also make the point that different users have different needs and that no training style is perfect or works for everyone.

It is difficult to generalize about trainee attitudes toward CBT in health care because individual experience varies, primarily due to improvements in software quality and instructional design over the years. In most studies of CBT in the 1990s, CBT is cited as the preferred method of training when compared to other methods. But, as researchers warn, it is easy to be seduced by the gimmicks of technology.

In cases where poor attitudes toward CBT are encountered, Miller and Wolf (1996) cite several keys to success in educational settings: (a) encourage students to use computers regularly; (b) link training with required curricular activities; (c) recruit more advanced students, who can serve as role models, to assist in teaching; and (d) focus on content areas in which students need help.



Use of CBT in Developing Countries

Though a small number of applications of CBT in developing countries has been reported, little research has been conducted on how much has been learned by health care workers and how well they are applying their learning. According to Howe (1993), "the educational effectiveness of CBT is unlikely to be any different in a developing country than in a developed one where most of the relevant surveys have been carried out." He also notes that the kinds of difficulties that might arise in developing countries, such as the instability of electricity and maintenance infrastructures, are not unique to CBT but apply to many other health interventions.

IMCI Tutorial, a CBT product developed by QAP to train health workers in the IMCI algorithm, was field-tested in Uganda in 1998. Results show that CBT students achieved equal scores with those taking the traditional IMCI course; furthermore, the CBT course was 20 percent less expensive to deliver. ModCal™, a CBT from Johns Hopkins Program for International Education in Reproductive Health (JPHIEGO), was introduced in the developing world in 1996 to train midwives. Results of a before-and-after pilot study in Zimbabwe demonstrated that midwives' test scores increased significantly by 24 percent after CBT training, and that prior computer use was not a factor in learning the content or in being able to maneuver through the program (Brechin et al. 1997).

Cuevas et al. (1993), a researcher with the Liverpool Epidemiology Programme, created a meningitis hypertext case study for use as an integral part of long-distance inservice training in epidemiology for international medical officers. He and his colleagues cite two advantages of using CBT in developing countries—the ability to copy the disk makes it possible to provide reference materials in places where up-to-date learning materials are often unavailable or cannot be shared due to lack of photocopying machines, and the freeing up of teachers and facilitators to devote more time to work with trainees on questions and problem solving. Unfortunately, the researchers were not able to test the effects of their program rigorously but could report it was extremely popular during its use.

WHO's Division of Control of Tropical Diseases developed a CBT on managing severe falciparum malaria. Though WHO did not evaluate this program, those involved in its use report that the costs saved in delivering training and the positive attitude of trainees towards the program has led to CBT programs on other tropical diseases (WHO 1995).

It would seem that project managers and donors should welcome the more cost-effective training provided by CBT (i.e., fewer days of training or self-instruction at the office with similar learning outcomes). Nevertheless, a strong bias toward traditional training in developing countries should be noted (Rosensweig 1992). The bias is often related to the need to provide incentives (in the form of per diem or stipend for attending training) to often-underpaid workers. Until other types of incentives are developed, the pressure to reward staff by offering training opportunities, especially outside the country, will remain strong.

Issues in Research Design

Based on Gagné's theory of instructional design (Gagné 1977), learning is optimized when supported by several components of the instruction process (e.g., gaining attention, informing learner of the objective, stimulating recall of prerequisite learning, presenting the stimulus material, assessing the performance). These events stimulate internal processing that, in turn, leads to quick, obstacle-free learning. If two instructional strategies aimed at the same learning outcome are based on the same events of instruction, they are comparable; if not, their comparability is questionable (Gilbert and Kolacz 1993). For example, imagine that CBT aimed at developing critical thinking was based on four events of instruction, and traditional training with the same aim was based on seven events of instruction. Any attempt to compare effectiveness would be confounded by these differences in design.

As CBT-control comparison studies have expanded over the years, other types of research studies remain to be conducted. Investigators involved in critical evaluation of the effectiveness and impact of CBT have reached the same conclusion as Gagné: What really matters is the quality of the underlying instructional design, not the medium by which it is presented. Application of an innovation implies not just a given technology medium (e.g., computers or books) but also a particular instructional content and particular methods (as represented in the software, programming, or text). The medium, content, and methods interact with features of the context within which the innovation is used and with the characteristics of the students involved. Thus, differences in test scores cannot be logically attributed to the medium used to teach; other variables, and interaction among these variables, all play a part in the results (U.S. Department of Education 1993). Further research is required to determine the factors—methodology, study setting, and CBT features—that affect learning, retention, and attitudes (Cohen and Dacanay 1994).

After conducting a seminal comprehensive review of hundreds of studies comparing CBT and other training formats, Clark (1983) concluded that all learning benefits attributed to one or another delivery medium in those studies were suspect. The lesson is that "learning outcomes are a function of instructional methods, not of the delivery media."

Clark (1985), Keane et al. (1991), and Friedman (1994) cite several biases that come into play, as follows:

- Different instructional methods (self-paced, case-based) used in the CBT and the control
- Different content presented in CBT and the control
- Different levels of curriculum material used in CBT and the control
- Different degrees of effort used in designing CBT and the control
- Different instructors developing CBT material and control-group material for varying content areas
- The novelty of newer media tending to increase the persistence and effort of students at the beginning of training but diminishing after four weeks
- CBT groups often having more instructional support than control groups

Clark advocates maintaining consistency between all variables to accurately assess the comparative effectiveness of CBT compared to control-group training modalities. To build a true case and control scenario, comparison studies should have the same content, branching options, teachers, and other variables. However, to hold everything except the medium constant, studies must sacrifice representativeness, comparing only a very circumscribed piece of content taught by both the new technology and a more traditional training method. Under such a scenario, it is likely that only a limited view of the effectiveness of CBT compared with traditional training would emerge (U.S. Department of Education 1993).

Friedman (1994) argues that "media-comparative study becomes logically impossible because there is no true comparison group." In his analysis of media-comparative studies, he points out that traditional and computer-trained groups cannot take the same test because, depending on the format chosen, the test would bias one of the groups. He argues that the branching offered in most CBT programs is not an option in traditional courses; thus comparisons of content are impossible. In addition, selecting participants for such studies is a flawed tactic, because it is unlikely that students would want to be randomized into studies if they believe participation may be harmful to their learning or career. Friedman questions if the very attractiveness of computer-based training derives from its ability to allow students to carry out sophisticated manipulations of three-dimensional graphics, view real-life clinical simulations, and simulate the management of patients in a variety of ways until they achieve optimal results, then how can CBT be compared to any other medium that does not offer these options?

The same problematic designs are evident in the studies featured in Tables 2 and 3. Richardson (1997) acknowledges that the comparison study in physiology training reviewed comparisons based on the presentation of *similar but not the same* material. After acknowledging this flaw, he advocates that identical material should be presented to separate classes by traditional and computer-assisted didactic lectures before definite conclusions can be drawn as to which method best helps students learn.

In Gaston's 1988 comparison study of the use of CBT and traditional training for nurses' research skills, the author states that the CBT and lecture groups studied had similar lesson content and objectives, yet the extent of other similarities and difference in instruction were not specified. Thus, the comparability of the instructional strategies is questionable according to Gilbert and Kolacz (1993). Additionally, attitudes expressed by students were misleading; they evaluated training effectiveness as a function of time rather than the degree to which learning was enhanced, which is what the author had intended.

Clark (1983), the leading critic of CBT research designs, considers one comparison study by Lyon et al. (1992) to be a benchmark research design. The researchers analyzed two years of trials in a double crossover trial where the intervention and control groups used the same two instructional methods and were able to control for all the common criticisms of comparison studies. In the study, all medical students of both second-year classes were stratified by sex and MCAT scores and randomized into an experimental group (using the computer-based program) and control group (using a traditional text version with the same content) for an anemia course. The next year, the controls became the experimental subjects and the experimental subjects became the controls for a similar intervention in a cardiology course. The researchers found that the experimental and control groups differed significantly only with respect to the amount of time spent on the courses, with the computer group able to complete the same content in less time than the text group with no loss in achievement.

Future of CBT

Two other new and increasingly popular ways of delivering computerized training are worth mentioning.

One is distance learning that, at its most basic level, takes place when teacher and student are separated by physical distance, and technology—sometimes involving occasional face-to-face communication—is used to bridge the instructional gap. An instructor, through e-mail or chat rooms on the Internet, can facilitate computer-based training in a distance learning approach. In an academic setting, this arrangement is known as a "virtual university."

Another increasingly popular option is networked training. Organizations that have already made heavy investments in computer networks are placing stand-alone CBTs on these networks for workers to access at their desktops. This paper does not discuss these innovations because the cost of Internet services and e-mail needed to deliver training through these computerized media is much too high for most developing countries.

Research and Implementation Needs

Apart from the pressing need to execute study designs other than those based on comparisons, several research questions have been identified by QAP as being of primary importance for future investigation and are briefly discussed below.

What are the alternatives to comparison studies?

Because it is generally agreed that studies comparing CBT and traditional training methods have large design limitations, one might ask what might be considered an optimum research design. Researchers such as Keane et al. (1991) advocate comparing different versions of the same CBT product to study the effectiveness of specific training features and provide insights into the learning process in health science programs. In their seminal study comparing modes of CBT delivery, Friedman et al. (1991) compared alternative formats for clinical simulations. Students worked on the same simulated computerized case, but in three different formats:
(a) a pedagogic format offering explicit educational support, (b) a high-fidelity format attempting to model clinical reasoning in the real world, and (c) a problem-solving format requiring students to express specific diagnostic hypotheses. This study revealed that students using the pedagogic format were more proficient, but less efficient, than their peers. They acquired more information but were able to do proportionately less with it. Based on this experience, Friedman advocated testing the educational value of CBT methods according to the unique features that the computer provides.

According to Reeves (1993), we need a multifaceted approach to research that involves intensive case studies. Reeves's view is that investigations into the effectiveness of interactive multimedia should include both observational and regression methods because of the exploratory nature of the research. Observational studies can identify the salient variable in learning, and multiple regression and computer modeling methods can determine causal relationships among these variables.

Many CBT programs can also be used at a learner's own pace, hence considerably reducing instructional time for some trainees.

Schwartz and Griffin (1993) compared optimum ways to deliver CBT for teaching medical students how to diagnose acute abdominal pain. They compared: (a) traditional CBT, using a question-and-explanation format, to learn domain knowledge; (b) diagnostic instruction CBT with outcome feedback; (c) diagnostic instruction with Bayesian feedback, (d) diagnostic instruction with Bayesian-plus-rules feedback; and (e) Delphic instruction CBT with Bayesian-plus-rules feedback. They found that all the experimental groups improved their diagnostic scoring, with the outcome-feedback group making the most improvement in accuracy. Members of this last group had received the correct diagnosis from the computer for each case after making their own diagnoses. Schwartz and Griffin concluded that it was the feedback alone (and not any specific type of feedback) that is essential to the most effective and efficient learning, and that "in a few hours, the students improved their diagnostic accuracy more than doctors do after six months in the emergency room."

In their study of students being trained in the anatomy and physiology of the liver and biliary tree, Devitt and Palmer (1999) looked at the use of different modes of CBT (didactic CBT, which differs little from a traditional lecture; problem-based CBT that stimulates thought and provokes the mind; and free text response CBT, in which users type in responses and then compare their responses with those generated by the author of the material). The investigators found that didactic CBT achieved significantly higher results than the other modes. They do admit in their study that students had no opportunity to work in groups but speculate that if this had been the case, the test sores would have been higher in the problem-solving program.

Raidl et al. (1995) studied the use of CBT to teach clinical-reasoning skills in the field of dietetics. They found that among three groups of students (those in a simulation test, those in a computerized drill-and-practice program plus simulation test, and those in a tutorial program plus simulation test), the ones in the simulation test alone scored highest, mastering all objectives for reasoning skills and decision-making.

There is still much more research to be done using this type of alternative comparison design.

What is the optimum mode of CBT delivery?

Researchers advocate studying various facets of CBT implementation and innovation and their specific effects, as well as how students and teachers use technology, rather than simply comparing two different delivery media in terms of a single outcome measure. When CBT is used as part of a course, do students benefit more from the program before or after participating in lectures and other educational experiences related to the course? How is traditional training enhanced with CBT, and what is the appropriate combination of facilitation and computer use? Are there learning situations in which groups of two or three students at a computer would be better than only one student at the computer? How much paper should students receive to work out problems or formulate written responses? These are some of the unanswered questions related to use of CBT as a stand-alone or supplement to other training such as tutorials, self-directed study, and clinical encounters.

What is the best way to measure cost-benefits derived from CBT?

According to Clark (1992a), given a specific instructional topic or problem, a particular combination of media will be used for training purposes; thus, an economic analysis of the various permutations of these instructional alternatives should be performed. Clark suggests that instructional programs be designed by matching economic objectives with learning objectives. The paucity of cost data pertaining to CBT does not include development costs. QAP is currently gathering cost data related to the testing and implementation of its CBT products.

Can CBT accommodate different learning styles?

Brain-hemisphere dominance could be considered a variable in learning propensity. People with left-brain dominance are believed to be primarily auditory learners, and those with right-brain dominance are thought to learn primarily through visual channels (Springer and Deutsch 1981). Some learners process information through multiple channels—e.g., visual, auditory, and kinesthetic. Benedict and Coffield (1989) conducted a study revealing that students with right-brain dominance scored higher in CBT while left-brain dominance students scored higher in traditional training. Some researchers advocate that CBT be designed to fit different learning styles (Lyon et al. 1992).

Kolb (1976) describes four recognized types of learners: (a) *assimilators* (abstract conceptualizers who rely on reflective observation), (b) *accommodators* (those who learn through concrete experience and active experimentation), (c) *divergers* (those who learn through concrete experience and reflective observation), and (d) *convergers* (those who learn through abstract conceptualization and active experimentation). In a study of attitudes towards CBT, Brudenell and Carpenter (1995) found differences among these four types of learners. Accomodators, convergers, and divergers demonstrated significantly fewer positive attitudes toward the particular function of the CBT that they were testing. Assimilators were significantly more negative in overall attitude. Khoiny (1995) hypothesized that accommodators and divergers would benefit most from CBT due to the concrete experiences the program provides. Their has been little exploration in this area, so QAP believes that further research needs to be done on ways to target appropriate CBT formats to different learning styles.

Can CBT be applied to QA training?

QAP has created the QA Kit (QAK), a multimedia training and reference program on quality assurance for health providers in developing countries.[9] Among the research questions that we plan to address when testing the QA Kit are:

- How can QAK be incorporated into QAP's current QA training approach?
- What is the role of a facilitator using QAK in QA training?
- How can QAK be modified as a stand-alone or as distance learning approach for QA training?
- Which aspects of QA are most appropriately delivered via computer?
- How can QAK be effectively implemented in a resource-strained environment?

Do CBT programs have to be adapted to each setting?

Few studies have examined whether locally developed CBT programs are applicable to similar courses in other curricula. This is important because CBT development often requires considerable time and expense. Applicability across curricula cannot be assumed because educational settings vary in content, language, objectives, and format of instruction (Toth-Cohen 1995). QAP hopes to explore the necessary requirements for adaptation of two project CBT products: the IMCI Tutorial for Latin America and the Tuberculosis Case Management Program for different countries in Africa.

What is the long-term effectiveness of CBT?

Most authors agree that some measure of long-term effectiveness needs to be added to the evaluation of CBT; however, few have applied them. Porter (1991) conducted a study of CBT used in paramedic education followed by an examination administered 60 days after the training. Lecture students' scores decreased the most (15.7 percent) in the intervening period, while scores for CBT students decreased the least (10.9 percent). Although problems associated with comparison studies have been cited, it is important that evaluation of CBT include information on long-term retention and performance of skills acquired through the training.

What is the best way to utilize software use-patterns?

Computers can generate log files of student branching patterns throughout the course of a CBT program. Unfortunately, few researchers have made use of this data, which could reveal a great deal about how trainees interact with CBT and their choice of pathways (Friedman et al. 1994). QAP advocates that audit trails be more thoroughly researched in current or future CBT products.

Conclusion

The experience of developing countries in applying computer technology to training needs in health care is still quite limited although highly encouraging, as is the more extensive application of CBT in developed countries. According to Kulik (1994), "… meta-analysts have demonstrated repeatedly that programs of computer-based instruction usually have positive effects on student learning. This conclusion has emerged from too many separate meta-analyses to be considered controversial." The benefits that health workers, no matter where they come from, will derive from any training modality will depend on how the material is presented, how it relates to carrying out their professional responsibilities, and ultimately on how assessment of the training affects the future delivery of health care. It has been widely observed that CBT is just as effective and possibly even more cost-effective than traditional training. Thus, more research should focus on the optimal delivery of CBT and the costs associated with this form of instruction.

Table 2 ■ Selected Studies on CBT Compared with a Noncomputerized Control in a Preservice Curriculum

Author	Target Group	Target Area *(Focus of Study)*	Description of Intervention	Statistically Significant Improvement	Other Findings
Day and Payne 1987	Nursing students	Health assessment (knowledge, performance, attitude, time)	Randomized quasi-experimental design incorporating two experimental treatments applied to two groups on two occasions: (a) CBT and (b) traditional lecture		No difference found on performance. No difference in time. Poor attitude toward CBT.
Gaston 1988	Nursing students	Nursing research (knowledge, retention, attitude)	A posttest with second posttest eight months later comparing two groups: (a) CBT and (b) lecture		No difference in knowledge, retention, or attitude
Andrews et al. 1992	Medical students	Dementia (knowledge)	Before and after study of two randomly assigned groups of students: (a) CBT and (b) teaching session	Both groups of students scored significantly better on the second test than on the pretest, but A scored significantly higher than B.	
Lyon et al. 1992	Medical students	Clinical problem solving in anemia and chest pain diagnosis (performance, time)	Stratified and randomized class of medical students for three different years into two crossover groups: (a) CBT and (b) textbook tutorial	Group A spent significantly less time (43%) on material to achieve same level of competence.	No difference in performance
Gilbert and Kolacz 1993	Nursing students	Medication administration	Randomized students in groups: (a) CBT and (b) 50 minutes of supplemental instruction through small-group review		No significant difference in performance between groups
Dewhurst et al. 1994	Medical students	Intestinal absorption (knowledge and attitude)	Pre- and posttest comparison of two groups: (a) CBT program with lecture and independent learning materials and (b) conventional practical class approach with lecturer and tutorials with teacher	Significant increase in attitude of group A over group B	Both groups: significant increase in knowledge but no difference between them
Halloran 1995	Nursing students	Medical/surgical nursing (knowledge)	Nonequivalent control group, posttest-only design comparing two groups of junior nursing students: (a) CBT and (b) lecture		No difference
Toth-Cohen 1995	Occupational health students	Anatomy and kinesiology (knowledge and attitude)	Two separate pilot studies were conducted at two universities using the same randomized experimental design comparing the learning outcomes of two groups of occupational therapy students: (a) CBT and (b) books	In the second study, group A scored significantly higher on the achievement test than group B. In both pilot studies, subjects displayed significantly more positive attitudes toward the CBT program as a learning tool than they did toward books.	No significant difference in the means on achievement test scores for the experimental and control groups in the first pilot study

continued on next page

Table 2 ■ *(continued)*

Author	Target Group	Target Area *(Focus of Study)*	Description of Intervention	Statistically Significant Improvement	Other Findings
Perciful and Nester 1996	Nursing students	Critical thinking (performance and knowledge)	Quasi-experimenal design observing two groups randomized into: (a) CBT and (b) student-faculty-service model	Group A scored significantly higher than group B on assessing, analyzing, and evaluating, as well as planning and implementation measures for critical thinking skills.	No difference in knowledge between groups
Kallinowski et al. 1997	Medical students	Surgical training (knowledge)	Randomized into two groups: (a) CBT program on digital radius fracture and (b) lecture	CBT group achieved 15–20% better scores than lecture group in all evaluated criteria (distinctness, detailed description, presentation of materials, structure, motivation to learn, time saved while learning, and memory retention).	
Christenson et al. 1998	Medical students	Advanced Cardiac Life Support Learning (ACLS) (performance and knowledge)	Convenience scheduling and comparison of two groups: (a) CBT and (b) traditional training		Both groups: equal in multiple choice exam and management of a mock cardiac arrest
Finley et al. 1998	Medical students	Auscultation of the heart	Students divided into: (a) computer-aided independent learning and (b) classroom teaching		Group B scored higher on open questions than group A. In general, performance by both groups was satisfactory and equivalent. Students of both groups repeatedly had difficulty classifying regurgitant and ejection murmurs and identifying characteristics of the second heart sound. Both CD-ROM and classroom teaching methods were highly rated by students, but most students preferred a combination.
Gee et al. 1998	Nursing students	Clinical pharmacology (knowledge)	A before and after validated multiple-choice test was administered to two groups: (a) CBT and (b) lecture	Clinical pharmacology test scores significantly improved for group A and were significantly higher than those of group B.	

Table 2 ■ *(continued)*

Author	Target Group	Target Area *(Focus of Study)*	Description of Intervention	Statistically Significant Improvement	Other Findings
Potts and Messimer 1999	Medical students	Pediatric fluid management	Comparison of two community-based medical school pediatric teaching services: (a) CBT and (b) traditional seminar	Scores on multiple choice and free text response exams were significantly higher for group A than B.	
Summers et al. 1999	Medical students	Surgical skills	Randomized into three treatment groups for basic surgical skills instruction: (a) didactic tutorial, (b) videotape, or (c) CBT	Groups B and C demonstrated statistically significant enhancement of technical skills compared with the didactic group. After one month, a calculated performance quotient revealed statistically significant improvement only in group C.	After treatment, higher scores on the multiple-choice question examination for group A

Table 3 ■ Selected Studies on CBT Compared with a Noncomputerized Control in an Inservice Curriculum

Author	Target Group	Target Area *(Focus of Study)*	Description of Intervention	Statistically Significant Improvement	Other Findings
Porter 1991	Paramedics	Trauma (knowledge and attitude)	Cross-sectional, prospective pretest, post-60-day evaluation study of three groups randomized into: (a) CBT, (b) video, or (c) lecture	Group A scored an average of 79.6% on the posttest, while lecture and video subjects scored 70.5% and 68.9%, respectively. At 60 days group A scored 70.9%, while groups B and C subjects averaged 59.4% and 59.1%, respectively.	Lecture preferred over CBT and video post-intervention and at 60 days
Brechin et al. 1997	Midwives in Zimbabwe	Reproductive training (knowledge)	Before and after study of a group of midwives using CBT	Scores on test increased significantly (by 24%).	
Kekitinwa and Tavrow unpublished	Front-line health workers in Uganda	Integrated management of childhood illness (knowledge, cost)	Participants from three districts in Uganda were randomly assigned to either the standard or IMCI training course.	CBT was 20% cheaper to deliver than a traditional course.	No significant difference in exam scores

Table 4 ■ Selected Studies on CBT Compared with Alternate Modes of CBT in a Preservice Curriculum

Author	Target Group	Target Area *(Focus of Study)*	Description of Intervention	Statistically Significant Improvement	Other Findings
Friedman 1991			Students randomized into three groups: a "pedagogic" format offering explicit educational support, a "high-fidelity" format attempting to model clinical reasoning in the real world, and a "problem-solving" format that required students to express specific diagnostic hypotheses	This study revealed that students using the pedagogic format were more proficient but less efficient (they acquired more information but were able to do proportionately less with it).	
Schwartz and Griffin 1993	Medical students	Diagnosis of acute abdominal pain (knowledge and performance with use of feedback)	Pretest and posttest randomized design of five groups: (a) traditional CBT, using a "question-and-explanation" format, to learn domain knowledge; (b) diagnostic-instruction CBT with outcome-feedback; (c) diagnostic-instruction with Bayesian feedback; (d) diagnostic-instruction with Bayesian-plus-rules feedback; and (e) Delphic instruction CBT with Bayesian-plus-rules feedback	Although the students in group a significantly improved their performance on multiple-choice questions (by 58%) compared with the other groups of students (6–10% improvement), these students did not improve their diagnostic performance. In contrast, the CBT groups that used simulated-patient cases and structured performance feedback did improve their diagnostic accuracy (by as much as 16%, compared with a 1% decline for the traditional CBT group).	
Raidl et al. 1995	Dietetics students	Clinical reasoning in dietetics (performance)	Randomized dietetics students and undergraduate diet therapy students enrolled in a coordinated program in dietetics (CPD) or a didactic program in dietetics (DPD) into: (a) drill-and-practice program plus simulation test, (b) tutorial program plus simulation test, and (c) simulation test only	Group B scored higher on the simulation test and mastered all objectives for lower-level reasoning skills and the higher-level decision-making objective than group A or C. As a group, the CPD students scored higher than the DPD students.	When CPD and DPD students were divided into the three experimental groups, there was no significant difference between the CPD and DPD student simulation scores.
Richardson 1997	Medical students	Physiology (knowledge and attitude)	Divided into three groups: (a) standard didactic lectures, (b) computer-assisted lectures, and (c) self-directed computer laboratory assignment	Exam scores for group C were significantly higher compared with those from either A or B.	Group A ranked significantly higher than B or C in student evaluations.
Devitt and Palmer 1999	Medical students	Anatomy and physiology of the liver and biliary tree (time and knowledge)	Students were randomly allocated to one of four groups: (a) problem-based CBT, (b) didactic CBT, (c) free text response CBT, or (d) traditional training control group. Students were tested before and after access to the program.	Group B performed significantly better than the other three groups on exam scores. Group C spent significantly less time on computer study.	Groups A and C response styles did no better in the posttest than did the controls.

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Footnotes

[1] For a review of continuing medical education, including training, see Davis et al. 1999.

[2] Among the other innovations are an increase in the use of distance-learning programs and alternate computer media, such as videos and audiotapes.

[3] Section C, Paragraph A.2 of the Statement of Work for QAP under USAID Contract No.HRN-C-00-96-90013 states that "the contractor shall also take advantage of major training interventions to introduce and evaluate innovative training approaches, such as computer-based training, which offers the potential for improved cost-effectiveness."

[4] Unless otherwise indicated, all the discussion in this paper refers to Level IV.

[5] For a review of IVI, see McNeil and Nelson, 1991.

[6] A few studies have demonstrated statistically significant improvements with the use of CBT among beginning and untrained students versus more experienced, older students.

[7] See project No. INT/96/P74 Computer Software and Support for Population Activities, which is designed to facilitate "the development of tools and methods to establish programs for the effective use of information communication application in learning systems for sustainable development."

[8] See Project No. 936-5846-00. Global Communication and Learning Systems (LearnLink) is designed to stimulate "the development of tools and methods to establish programs for the effective use of information communication application in learning systems for sustainable development."

[9] QA Kit is one of three multimedia training programs developed by QAP. The others are the Integrated Management of Childhood Illness (IMCI) Tutorial and Tuberculosis (TB) Case Management. All are in varying stages of production and field-testing.